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Fukui

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(54) **MOTOR AND MANUFACTURING METHOD OF MOTOR**

(71) Applicant: **MINEBEA MITSUMI Inc.**, Nagano (JP)

(72) Inventor: **Yasushi Fukui**, Nagano (JP)

(73) Assignee: **MINEBEA MITSUMI Inc.**, Nagano (JP)

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H02K 7/00 (2006.01)

(52) **U.S. Cl.**
CPC ***H02K 7/003*** (2013.01)

(58) **Field of Classification Search**
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USPC .... 310/75 D
See application file for complete search history.

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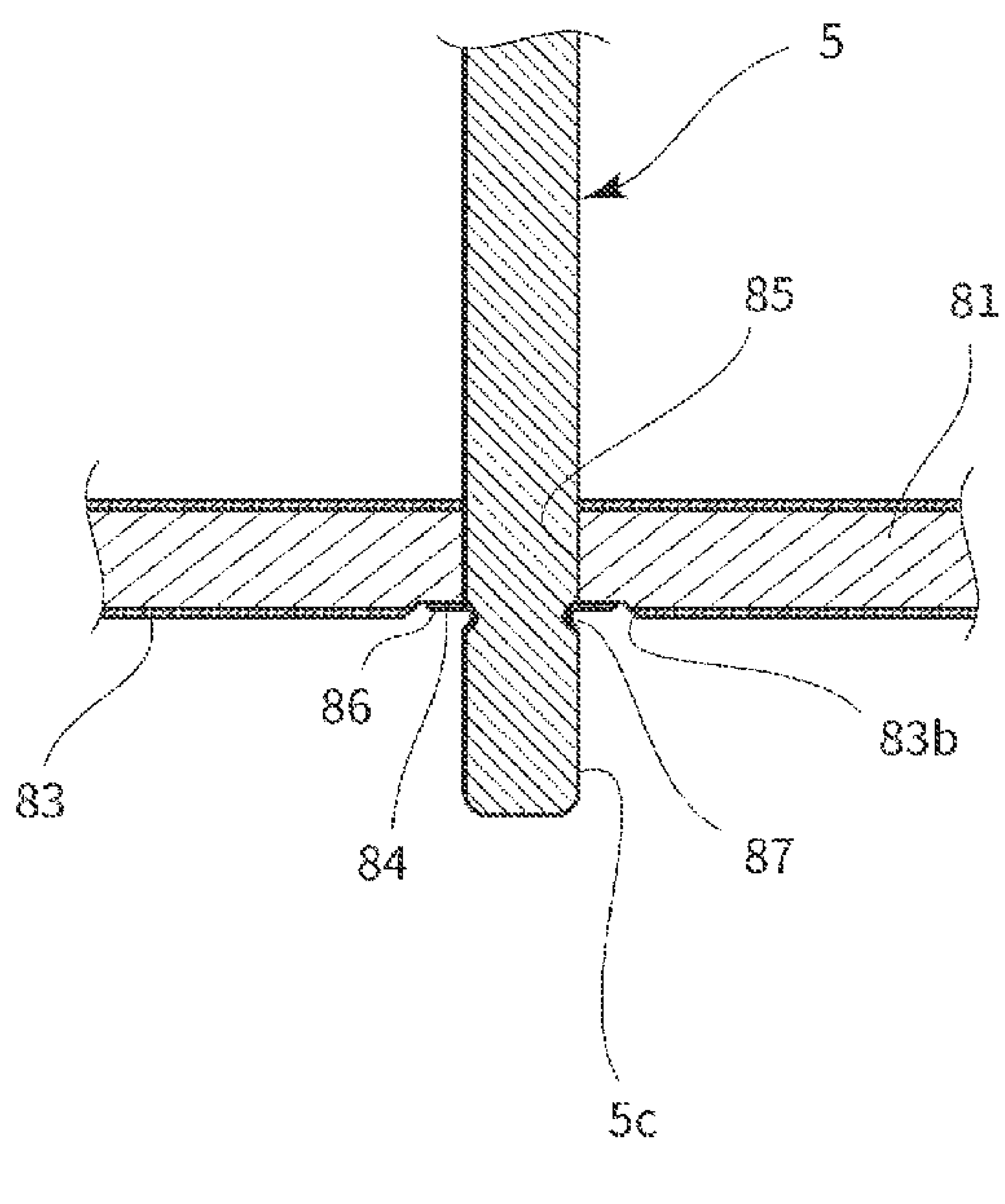
Primary Examiner — Terrance L Kenerly
(74) *Attorney, Agent, or Firm* — Pearne & Gordon LLP

(57) **ABSTRACT**

Provided is a motor including a shaft welded to or fused with a metallic member. The motor includes a shaft (**5**) made of metal and a base including a metal board (**81**) covered with a coating layer (**83**). The coating layer (**83**) has an opening (**83***b*), and the metal board (**81**) includes a recessed part (**84**) exposed through the opening (**83***b*). An outer peripheral part of the shaft (**5**) and the recessed part (**84**) are fused or welded together.

8 Claims, 5 Drawing Sheets



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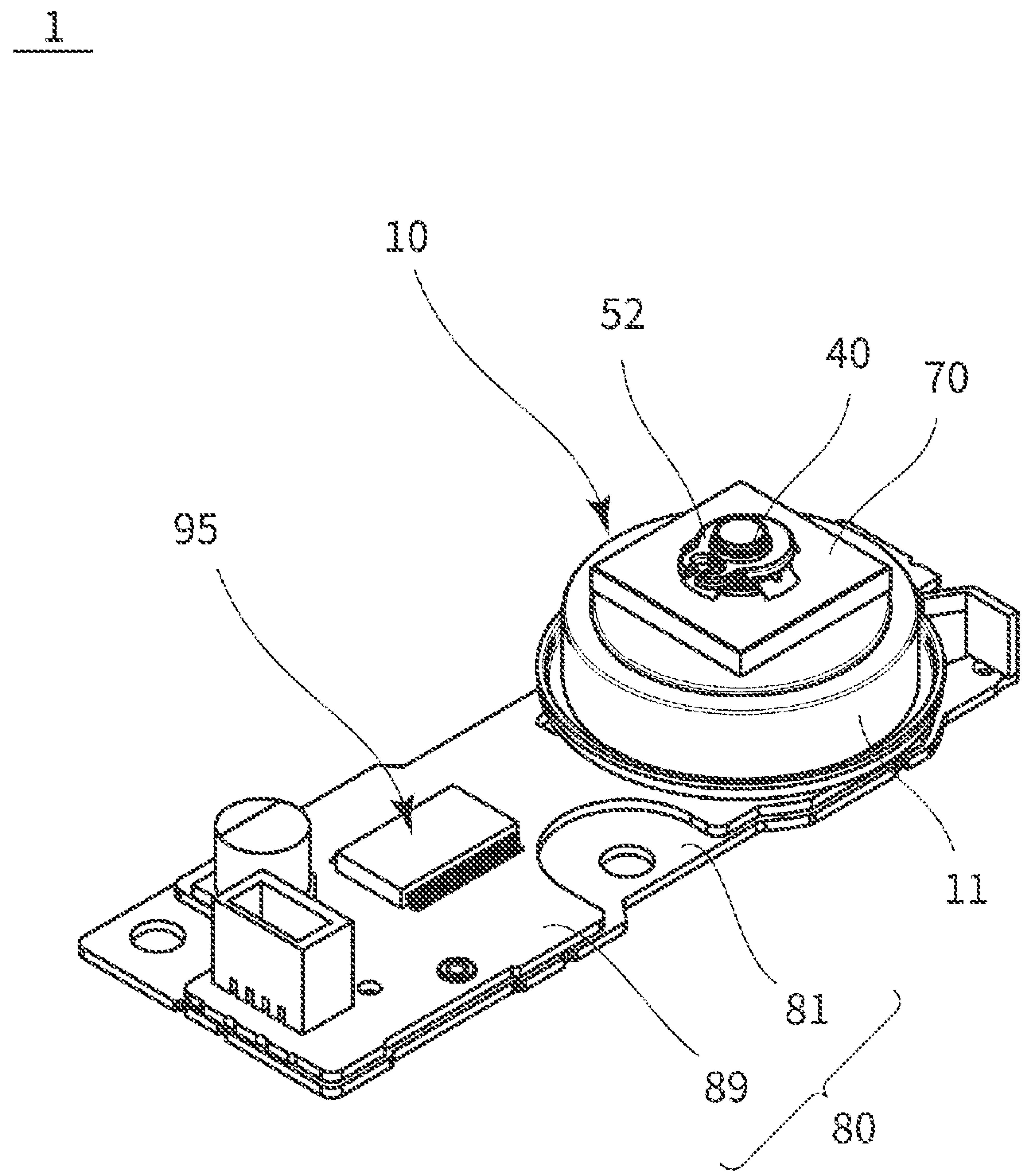

FIG.1

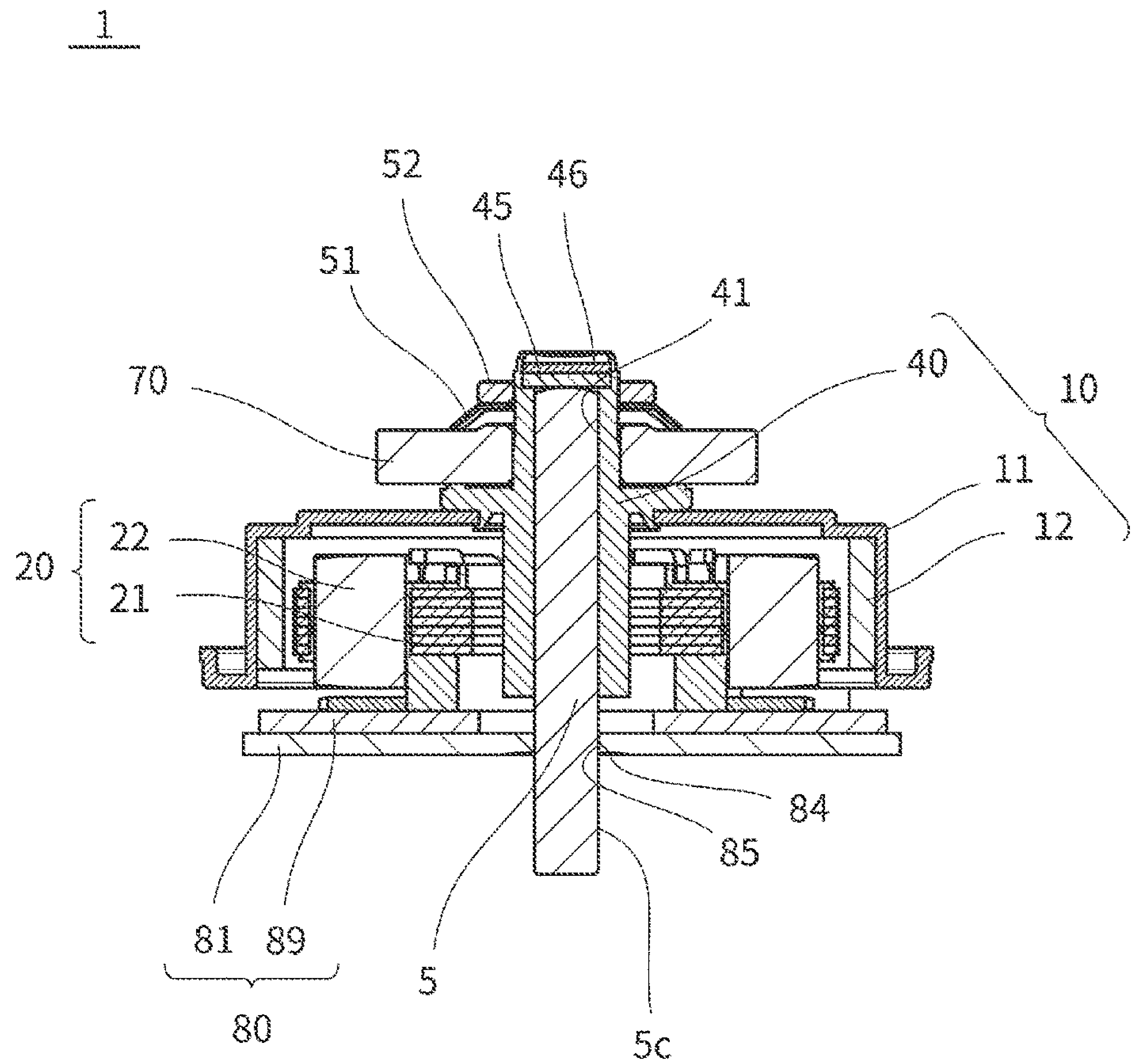
1
52
45
46
51
41
70
40
10
11
12
20
22
21
84
85
81
89
5
80
5c

FIG.2

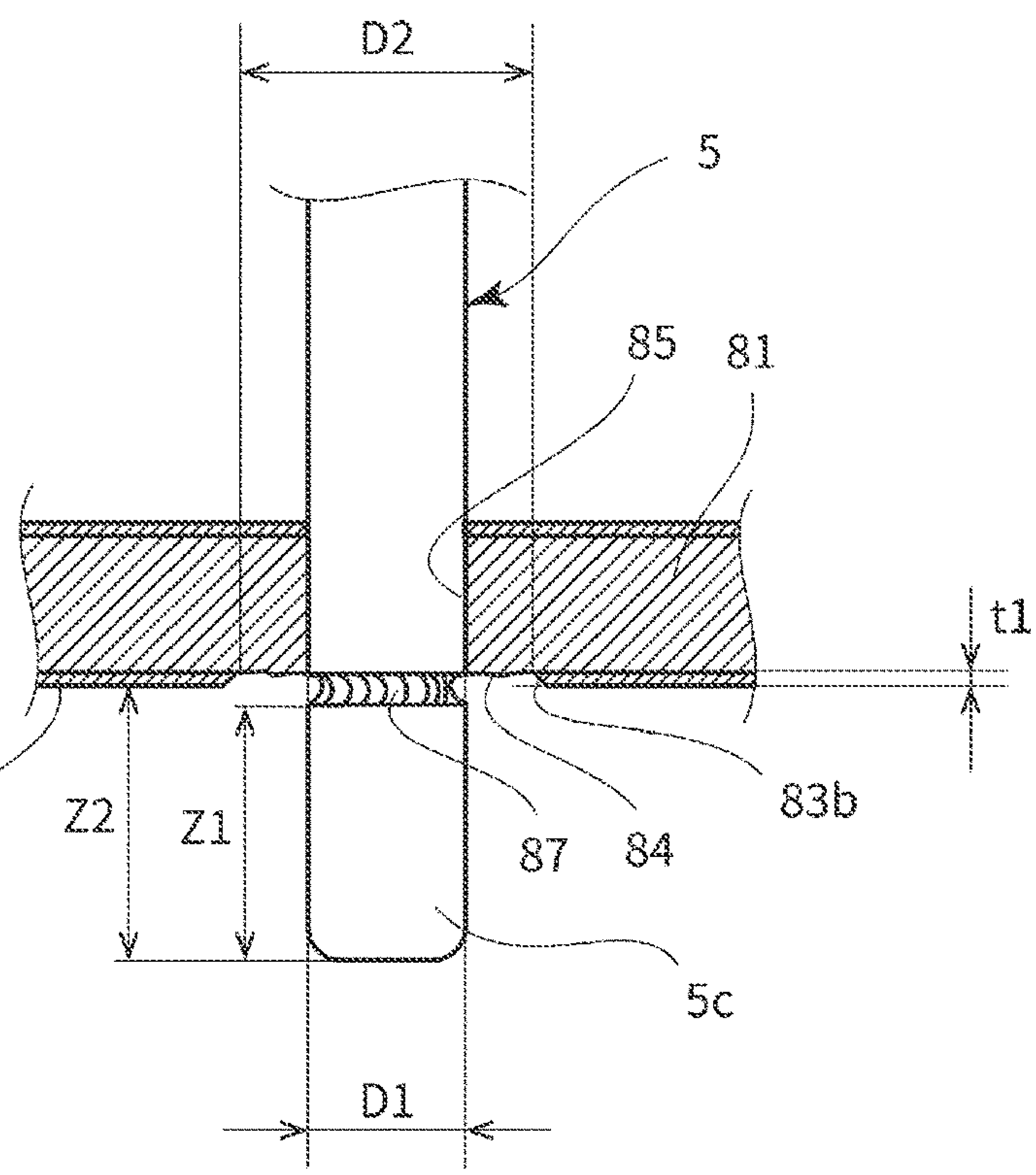
D2
5
85
81
t1
83b
83
Z2
Z1
87
84
5c
D1

FIG.3

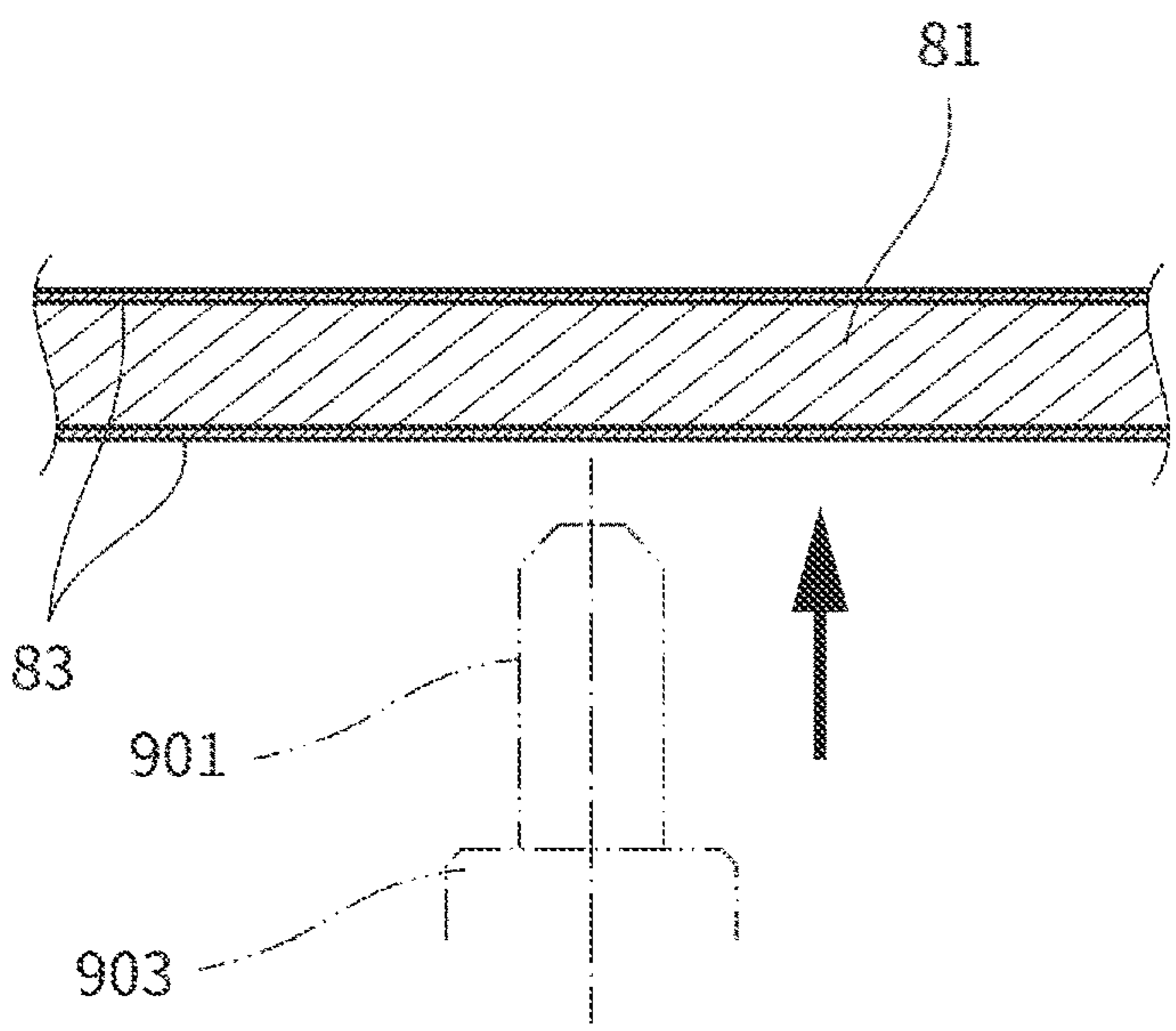

FIG.4

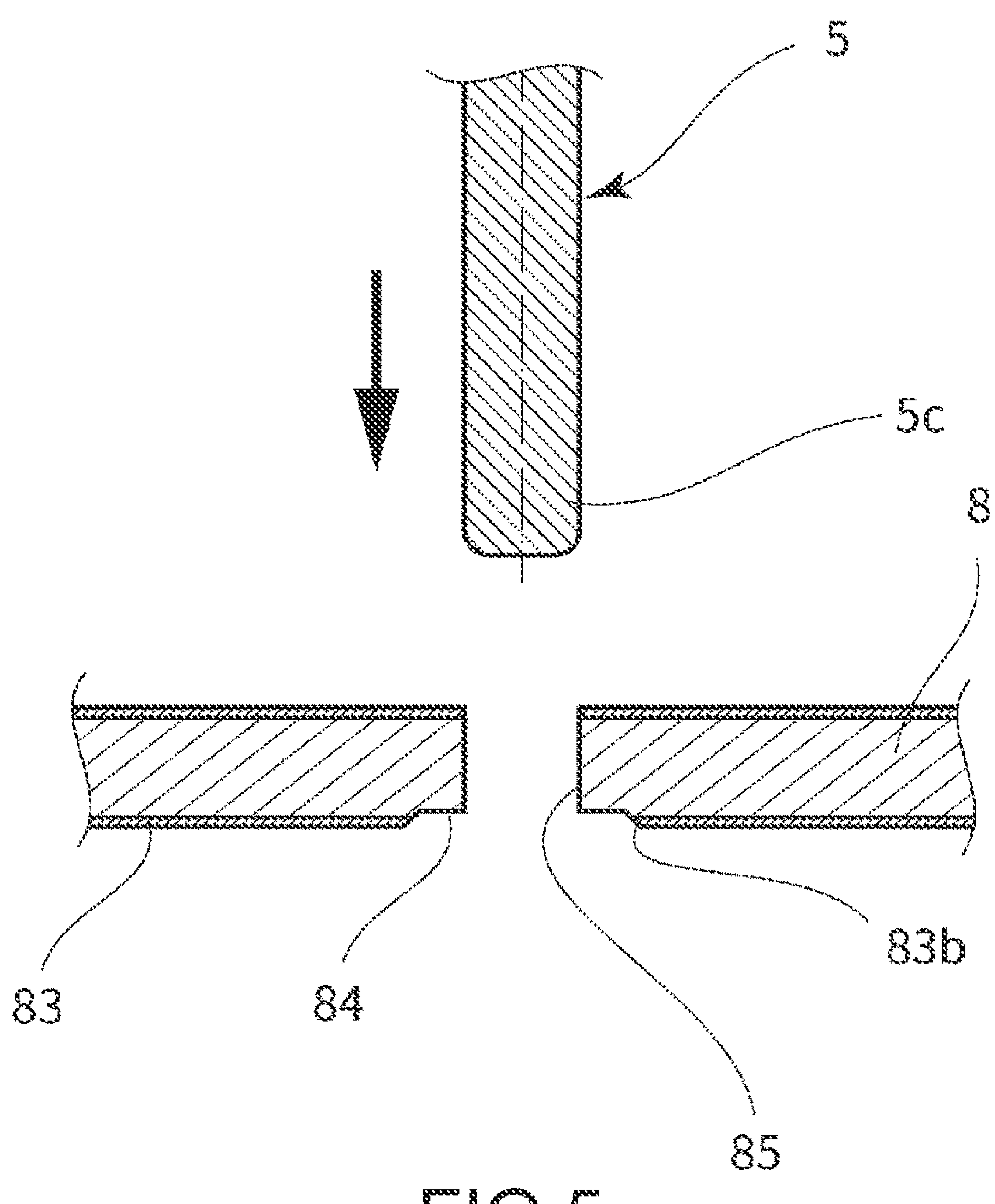

FIG.5

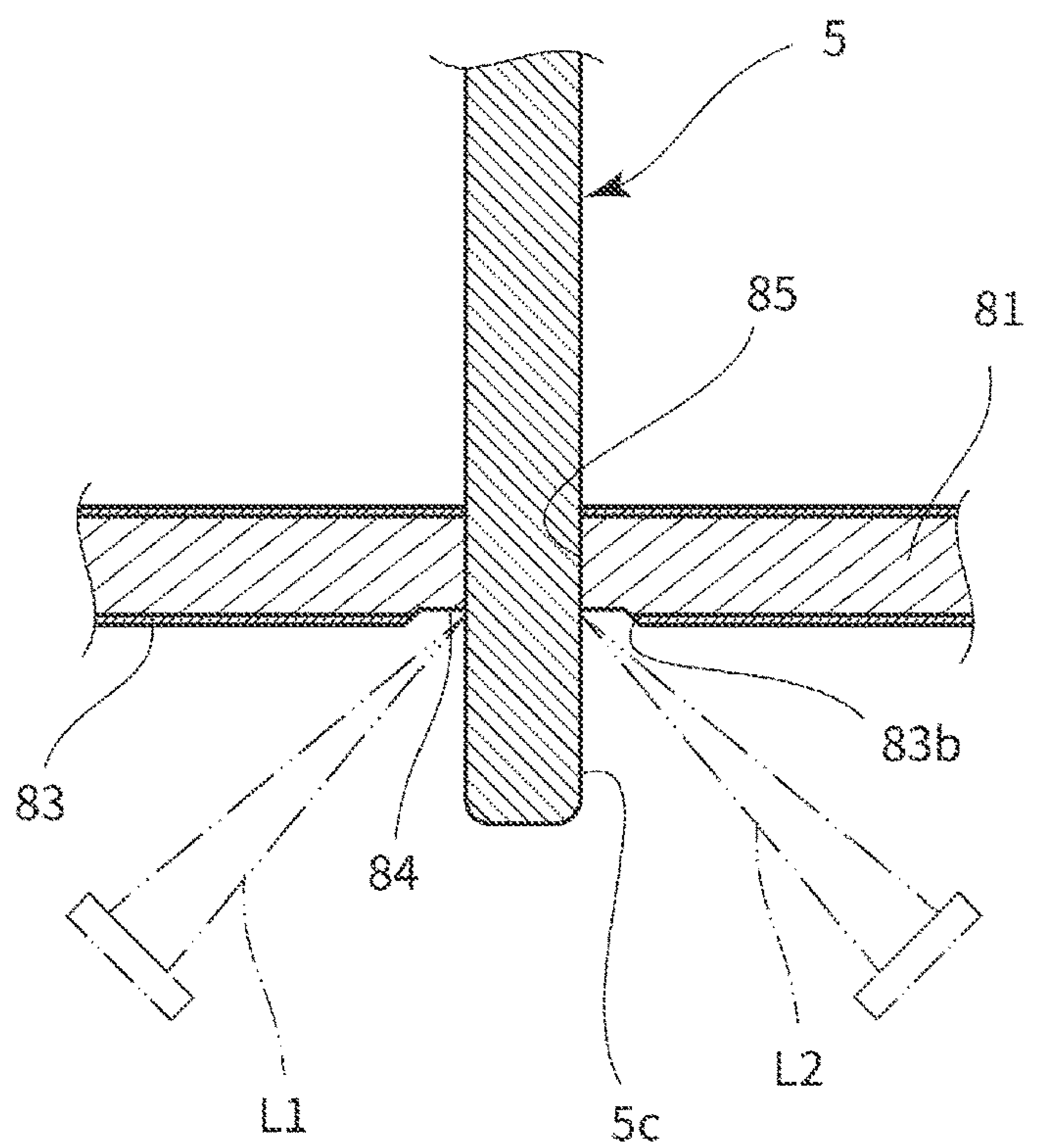

FIG.6

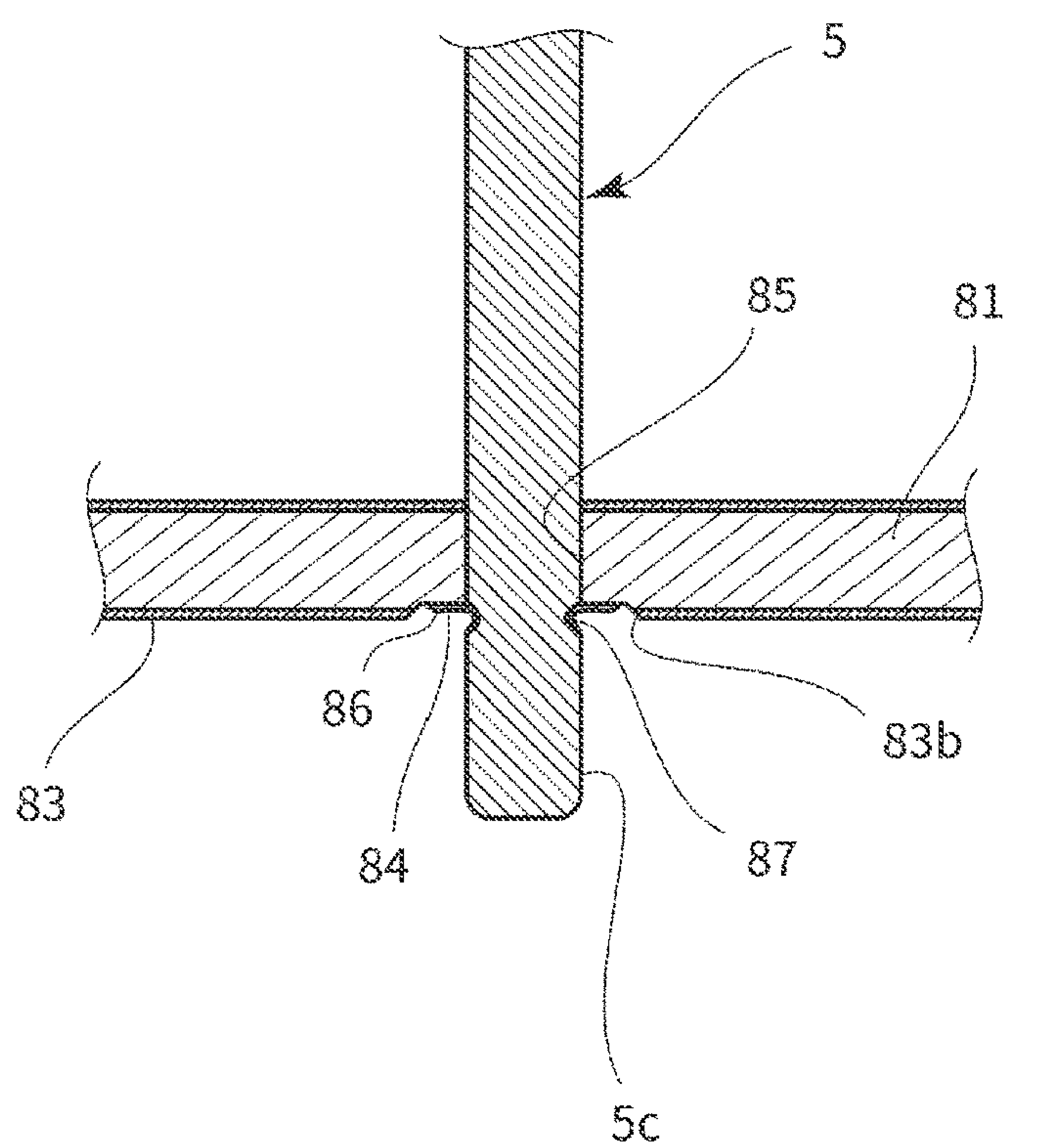

FIG.7

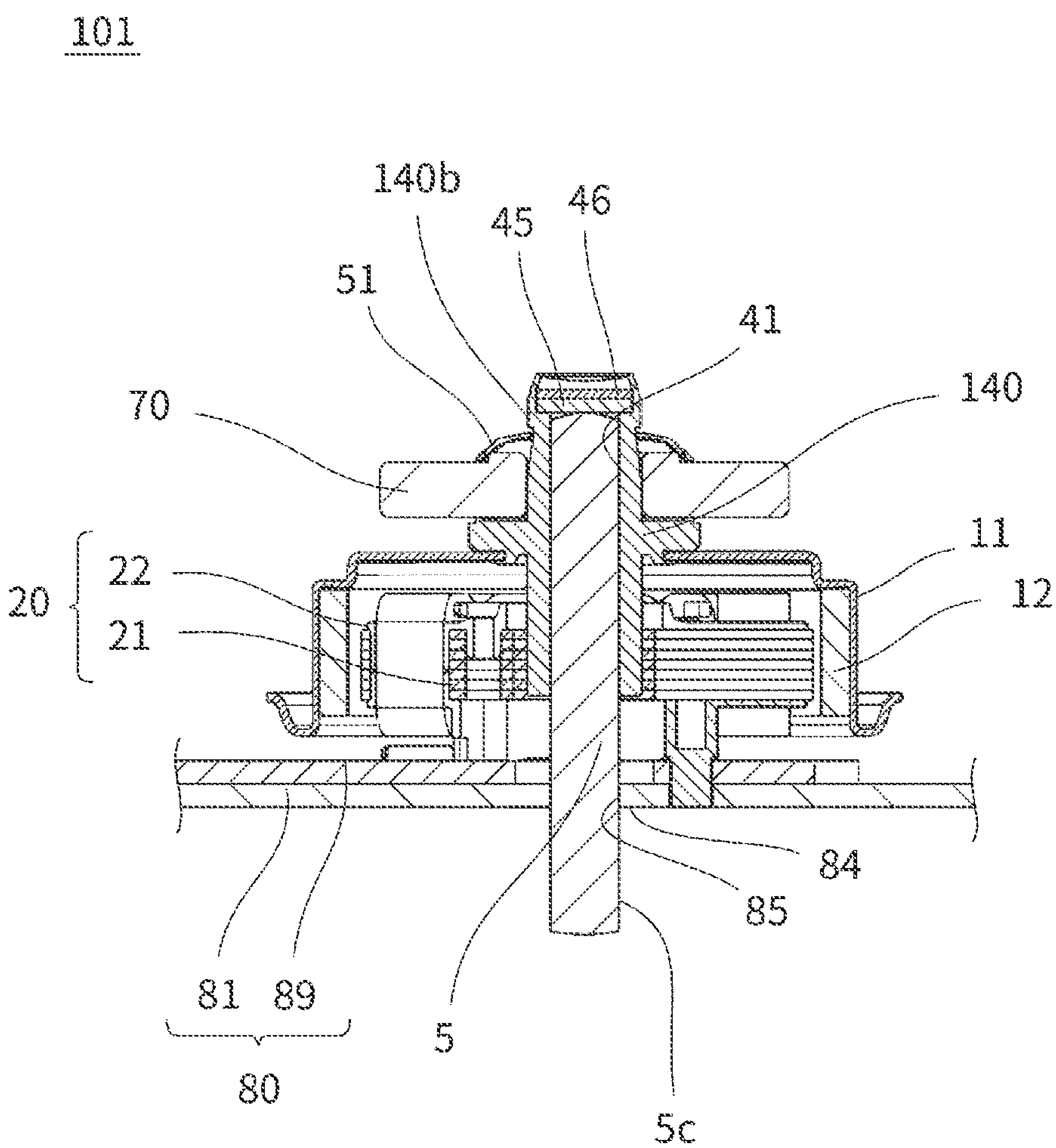

FIG.8

MOTOR AND MANUFACTURING METHOD OF MOTOR

TECHNICAL FIELD

The present invention relates to a motor and a method for manufacturing a motor, and particularly relates to a motor including a shaft welded to or fused with a metallic member and a method for manufacturing such a motor.

BACKGROUND ART

It is known that in a structure of some conventional motors, a shaft is welded to or fused with a metallic member.

Patent Literature 1 shown below discloses performing laser welding to join a shaft of a rotator of a motor or a similar machine to a flat plate by irradiating a joint between the shaft and the flat plate with laser beams while rotating the flat plate.

DOCUMENT LIST

Patent Literature

Patent Literature 1: Japanese Patent Application Publication No. 2004-090030

SUMMARY OF INVENTION

Technical Problem

It is an object of the present invention to provide a motor including a shaft welded to or fused with a metallic member and a method for manufacturing such a motor.

Solution to Problem

A motor according to an aspect of the present invention, accomplished to attain the object described above, includes: a shaft made of metal; and a base including a metallic member covered with a coating layer, wherein the coating layer has an opening, the metallic member includes an exposed part exposed through the opening, and an outer peripheral part of the shaft and the exposed part are fused or welded together.

Preferably, the outer peripheral part of the shaft has a recessed face extending in a peripheral direction, and the recessed face and the exposed part are fused or welded together.

Preferably, the outer peripheral part of the shaft has a cylindrical face, the recessed face and the cylindrical face are lined in a longitudinal direction of the shaft, and the recessed face is entirely inside the cylindrical face in a radial direction.

Preferably, the base is formed with a resin member, and wiring is formed at the resin member.

Preferably, the coating layer contains zinc.

Preferably, the shaft is made of martensitic stainless steel containing no lead.

Preferably, the motor includes: a rotor able to rotate relative to the shaft; and a polygon mirror attached to the rotor.

Preferably, the motor includes a bearing, wherein the polygon mirror is disposed at the bearing.

A method for manufacturing a motor, according to another aspect of the present invention, includes: a first step of removing a part of a coating layer coating a metallic member covered with the coating layer; and a second step of fusing or welding an outer peripheral part of a shaft made of metal to an exposed part of the metallic member, the exposed part being exposed in the first step.

Preferably, in the first step, a hole is formed in the metallic member by a cutting tool and the coating layer around the hole is cut to partially remove the coating layer, and in the second step, the outer peripheral part of the shaft inserted into the hole and the exposed part are fused or welded together.

According to these aspects of the present invention, a motor including a shaft welded to or fused with a metallic member and a method for manufacturing such a motor may be provided.

BRIEF DESCRIPTION OF DRAWINGS

FIG. **1** A perspective view illustrating an example of a motor according to an embodiment of the present invention.

FIG. **2** A cross-sectional view of the motor.

FIG. **3** A cross-sectional view illustrating a part of a joint between a metal board and a shaft.

FIG. **4** A first drawing illustrating a manufacturing process for a motor.

FIG. **5** A second drawing illustrating the manufacturing process for the motor.

FIG. **6** A third drawing illustrating the manufacturing process for the motor.

FIG. **7** A fourth drawing illustrating the manufacturing process for the motor.

FIG. **8** A cross-sectional view of a motor according to a modification example of the present embodiment.

DESCRIPTION OF EMBODIMENTS

Hereinafter, an embodiment of the present invention will be described with reference to the drawings.

For the present embodiment, a description is given of a motor (a polygon mirror scanner motor) designed to rotate a polygon mirror used for laser scanning by a laser beam printer or other devices.

Embodiment

FIG. **1** is a perspective view illustrating an example of a motor **1** according to an embodiment of the present invention. FIG. **2** is a cross-sectional view of the motor **1**.

In the following description, a direction away from a polygon mirror **70** and toward a base plate **80** along a shaft **5** (a downward direction in FIG. **2**) may be referred to as a downward direction and a direction away from the base plate **80** and toward the polygon mirror **70** along the shaft **5** (an upward direction in FIG. **1**) may be referred to as an upward direction.

With reference to FIGS. **1** and **2**, the motor **1** according to the present embodiment is used to drive the polygon mirror **70** attached to a rotor **10**. The motor **1** mainly includes the shaft **5**, the rotor **10**, a stator **20**, the polygon mirror **70**, and the base plate **80**.

The shaft **5** is fixed to the base plate **80**. The stator **20** is disposed above the base plate **80**. The rotor **10** is attached to the shaft **5** so as to be rotatable relative to the shaft **5**.

The rotor **10** includes a frame **11**, a magnet **12**, and a sleeve **40** (an example of a bearing).

The frame **11** is for preventing leakage of a magnetic field from inside the frame **11** and is, for example, made from a magnetic body. The frame **11** has a part extending in a direction perpendicular to the shaft **5** (an outer peripheral direction, a lateral direction in FIG. **2**) and a part extending in a direction parallel to the shaft **5** (an up-down direction in FIG. **2**) to constitute a side wall. The frame **11** has a cylindrical shape having a closed upper portion and an opening at the bottom.

The magnet **12** is annular and, more specifically, has a cylindrical shape. The magnet **12** is attached to an inner wall surface of an outer peripheral part of the frame **11**.

The sleeve **40** extends in the up-down direction so as to pass through a central part of the frame **11**. The sleeve **40** is fixed to a hole formed in a middle of an upper surface of the frame **11**. The polygon mirror **70** is fixed to an upper portion of the sleeve **40**. A middle of the sleeve **40** forms a cylindrical part **41** as a tubular portion, and the shaft **5** is inserted inside the cylindrical part **41**. A gap between the sleeve **40** and the shaft **5** is, for example, filled with a lubricant to form a dynamic fluid pressure bearing in a radial direction. This enables the rotor **10** to rotate relative to the shaft **5**. An inside of the cylindrical part **41** of the sleeve **40** has herringbone grooves (not illustrated). The herringbone grooves are formed at two locations separately in an axial direction. However, the scope of the present invention is not limited to this example.

A thrust plate **45** and a thrust cover **46** are attached to an upper portion of the cylindrical part **41** of the sleeve **40**. The thrust cover **46** covers an upper end portion of the cylindrical part **41**. The thrust plate **45** is disposed between the thrust cover **46** and an upper end face of the shaft **5**.

The stator **20** includes a stator core **21** having a plurality of teeth formed so as to extend from a middle outward radially and a stator coil **22** wound around the teeth. The stator **20** is disposed on an inner periphery side of the magnet **12** so as to face the magnet **12** through a space. The stator coil **22** generates a magnetic field when an electric current flows in the stator coil. An interaction between the magnetic field of the stator coil **22** and a magnetic field of the magnet **12** generates driving force (force enabling the rotor **10** to rotate).

The polygon mirror **70** is fixed to the upper portion of the sleeve **40** and is positioned above the frame **11**. The polygon mirror **70** is arranged between a spring **51** disposed above and a part of the sleeve **40**, and is fixed there. A grip ring **52** is disposed in the upper portion of the spring **51**, and the position of the up-down direction of the spring **51** is put in proper position by the grip ring **52**.

The base plate **80** (an example of a base) has a metal board **81** (an example of a metallic member) and a circuit board **89** (an example of a resin member). The circuit board **89** is layered on an upper surface of the metal board **81** to constitute a single base plate **80**.

The circuit board **89** is, for example, a printed wiring board. The printed wiring board is a resin member, and wiring is formed on the resin member. The resin member is, for example, made of an epoxy resin. An electronic component **95** is populated at an upper surface (a surface on an upper side in FIG. **1**) of the circuit board **89** via solder. The electronic component **95**, for example, includes a drive and control integrated circuit to drive and control the motor. The electronic component **95** is joined to the upper surface of the circuit board **89** with solder. A variety of circuit elements, other than the integrated circuit, may be disposed on the circuit board **89**. Such circuit elements are, for example, a Hall element used to detect a rotation angle or a rotation number of the magnet **12** based on a change in magnetic field received from the magnet **12**, chip-type circuit elements (a resistor, a capacitor), and a drive integrated circuit (IC) used to turn on or off the application of an electric current to each stator coil **22**.

The metal board **81** is, for example, composed of a board made of iron. A hole **85** is formed in the metal board **81**. The shaft **5** is inserted into the hole **85**. The shaft **5** and the metal board **81** are firmly fixed to each other by laser welding a joint of the shaft **5** and the hole **85** on a lower surface side of the metal board **81**, as described later. The motor **1** is manufactured, after the shaft **5** is fixed to the metal board **81**, by attaching the circuit board **89** to the metal board **81**, and attaching the stator **20** and the rotor **10**.

The shaft **5** has a protrusion **5***c* protruding downward from the base plate **80**. When the motor **1** is mounted to a device or another apparatus using the motor **1**, the protrusion **5***c* provided for the motor **1** allows the motor **1** to be put in proper position by fitting the protrusion **5***c* into a hole formed in the device side. Since an axis of the protrusion **5***c* coincides with a rotation axis of the polygon mirror **70** of the motor **1**, the polygon mirror can be put in proper position readily and precisely with respect to the device using the motor **1**.

FIG. **3** is a cross-sectional view illustrating a part of the joint between the metal board **81** and the shaft **5**.

In FIG. **3**, the metal board **81** and the shaft **5** are shown, and other components are not shown. A cross section of the metal board **81** taken along a central axis of the shaft **5** is shown.

In the present embodiment, the metal board **81** is a sheet of galvanized steel pertinent to Japanese Industrial Standards (JIS) symbols such as "SECC", "SECD", "SECE", "SECF", and "SECG" specified by JIS standard numbers. In other words, a surface of the metal board **81** is covered with a coating layer **83**. The metal board **81** has the coating layer **83**, the coating layer **83** being a zinc coating layer. The coating layer **83** covers each of the upper surface and a lower surface. The coating layer **83** is provided for anticorrosion purposes. In FIG. **3** and subsequent drawings, the coating layer **83** is schematically shown. The metal board **81** is made from a sheet of galvanized steel. The sheet of galvanized steel is in general circulation and widely available. This contributes to a reduction in manufacturing costs for the motor **1**.

The shaft **5** is composed of a metallic member. In the present embodiment, the shaft **5** is made of martensitic stainless steel containing no lead. The shaft **5** is, for example, made of stainless steel pertinent to JIS symbols such as "SUS420F", "SUS420J2", "SUS420J1", "SUS403", "SUS410", "SUS416", "SUS431", and "SUS440C" specified by JIS standard numbers. The shaft **5** has a composition excellent in wear resistance, offers improved machinability, and has no lead added as a constituent (contains virtually no lead). Thus, the martensitic stainless steel containing no lead refers to stainless steel. Stainless steel has no lead added as a constituent (contains virtually no lead). The shaft **5** is made of stainless steel containing manganese as a constituent. This example, however, does not limit the material for the shaft **5**.

In FIG. **3**, the metal board **81** has a recessed part **84** (an example of an exposed part) in a surface on a lower side of the metal board **81**. The recessed part **84** is, for example, a zone having a diameter D2 in size and being recessed upward from the surface of the metal board **81** by a dimension t**1**. The recessed part **84** is formed to be substantially concentric with the hole **85**. A depth of the recessed part **84** (the dimension t**1**) is slightly greater than a thickness of the coating layer **83**. The recessed part **84** is formed by cutting the surface of the metal board **81**, as described later.

In other words, because of the recessed part **84** thus formed, the coating layer **83** on the lower side has an opening **83***b*. To put it another way, the metal board **81** has an exposed part (the recessed part **84**) to allow an iron portion not covered with the coating layer **83** to be exposed downwardly through the opening **83***b* formed in the coating layer **83**.

The shaft **5** is inserted into the hole **85** so as to pass through the metal board **81**. A diameter D**1** of the shaft **5** is slightly smaller than an inner diameter of the hole **85**.

For instance, in the present embodiment, the dimension t**1** is a dimension ranging from 0.01 mm to 0.1 mm inclusive, the diameter D**1** is 2.368 mm±0.0005 mm, and the diameter D**2** is a dimension ranging from 3.3 mm to 4.8 mm inclusive. The inner diameter of the hole **85** is a dimension ranging from 2.0 mm to 5.0 mm inclusive.

An outer peripheral part of the shaft **5** protruding downward from the hole **85** and the recessed part **84** are welded by laser welding. The welding is applied to an entire periphery of the shaft **5**. Owing to the welding, a recessed face **87** recessed in a radial direction is formed at an upper end portion of a part of the shaft **5** protruding downward from the recessed part **84**. The recessed face **87** extends in a peripheral direction along the shaft **5**. The recessed face **87** extends in a peripheral direction throughout the periphery of the shaft **5**. A welding mark is formed at a surface of the recessed face **87**. An alloy formed when welding appears as a welding mark at a surface of the recessed part **84** in a neighborhood of the shaft **5**. In other words, the recessed face **87** and the recessed part **84** are welded and joined to each other.

The outer peripheral part of the shaft **5** has a cylindrical face. The protrusion **5***c* and the recessed face **87** are lined in a longitudinal direction of the shaft **5**. The recessed face **87** is entirely inside a cylindrical face of the protrusion **5***c* in a radial direction. In other words, of the part where the recessed face **87** is formed, no part of the recessed face **87** is outside an outer peripheral surface of the shaft **5** having the diameter D**1**.

In this way, the recessed face **87** is formed at the shaft **5**. Thus, in a dimension Z**2** of the shaft **5** protruding downward from the lower surface of the metal board **81**, the cylindrical face of the shaft **5** formed with high precision is ensured throughout a dimension Z**1** other than a part of a dimension along the up-down direction of the recessed face **87**. This allows the motor **1** to be put in proper position with high precision using the protrusion **5***c* because the dimension Z**1** of the cylindrical face of the shaft **5** in the up-down direction can be ensured to a relatively large extent. The device having the motor **1** can be downsized because the dimension Z**2** of the shaft **5** protruding downward can be made relatively small.

In a manufacturing process for the motor **1**, the shaft **5** is fixed to the metal board **81** in steps described below. The motor **1** is manufactured, after the shaft **5** is fixed to the metal board **81** as described below, by attaching the circuit board **89** implemented with the electronic component **95** and other elements to the metal board **81**, and attaching the stator **20** and the rotor **10** to the base plate **80**.

FIG. **4** is a first drawing illustrating a manufacturing process for the motor **1**.

First, as illustrated in FIG. **4**, the hole **85** is formed in the metal board **81** by a cutting tool **901** such as a drill, an end mill, and a reamer. Together with the formation of the hole **85**, the coating layer **83** around the hole **85** is cut to partially remove the coating layer **83**. This forms the recessed part **84** together with the hole **85**. The coating layer **83** can be partially removed in the same step for the formation of the hole **85**, for example, by processing the metal board **81** from underneath using a second cutting tool **903** coaxially arranged with the cutting tool **901**, the second cutting tool **903** being, for example, an end mill or a file. This helps shorten the manufacturing process. The formation of the hole **85** and the removal of the coating layer **83** (the formation of the recessed part **84**) may be performed in separate steps. The tools and the technique used for the formation of the hole **85** and the removal of the coating layer **83** are not limited to the examples described above. For instance, the hole **85** may be formed by press working.

FIG. **5** is a second drawing illustrating the manufacturing process for the motor **1**.

Thereafter, as illustrated in FIG. **5**, the shaft **5** is inserted into the hole **85**. The shaft **5** is preferably inserted from above the metal board **81**.

FIG. **6** is a third drawing illustrating the manufacturing process for the motor **1**.

Subsequently, as illustrated in FIG. **6**, with part of the shaft **5** being inserted into the hole **85**, laser welding of the outer peripheral part of the shaft **5** and the recessed part **84**, as an exposed part, is performed. During welding, the metal board **81** and the shaft **5** are rotated relative to two lasers L**1** and L**2** such that two places in the neighborhood of a joint between the recessed part **84** close to the hole **85** and the shaft **5** are points irradiated with beams from the respective lasers L**1** and L**2**. For instance, the metal board **81** and the shaft **5** are rotated around the shaft **5** by 180 degrees without any change in positions of the lasers L**1** and L**2** such that the points irradiated with beams from the two respective lasers L**1** and L**2** are 180 degrees apart from each other around the shaft **5**. This means that the outer peripheral part of the shaft **5** and the recessed part **84** are welded together around the entire periphery and the shaft **5** may be fixed to the metal board **81**. Laser welding is preferably performed with the shaft **5** and the metal board **81** being upside down (the protrusion **5***c* of the shaft **5** positioned so as to face upward).

FIG. **7** is a fourth drawing illustrating the manufacturing process for the motor **1**.

In FIG. **7**, a condition after the laser welding is performed is schematically illustrated. Because of the laser welding being performed, a portion of the outer peripheral part of the shaft **5** and a portion of the recessed part **84** melt to constitute a welded part **86** forming a welding mark. Since a part of the shaft **5** melts and is carried to constitute the welded part **86**, the recessed face **87** is formed on the outer peripheral surface of the shaft **5**. In the recessed part **84**, the welded part **86** extends in a radial direction from the neighborhood of the hole **85**. The welded part **86** stays inside the recessed part **84**. In other words, a size of the recessed part **84** is set such that the welded part **86** does not extend in a radial direction beyond the recessed part **84**. This prevents the welded part **86** from protruding from the surface of the metal board **81**, and allows the motor **1** to be put in proper position with increased precision with the surface of the metal board **81** as a reference surface.

In the present embodiment, as described above, the motor **1** is formed by a manufacturing method including a step of removing part of the coating layer **83** of the metal board **81** covered with the coating layer **83** and a step of welding the outer peripheral part of the shaft **5** made of metal to the recessed part **84** of the metal board **81**, the recessed part **84** having been exposed in the removing step. In other words, in the structure of the motor **1**, the recessed part **84** of the metal board **81** and the outer peripheral part of the shaft **5** are welded together. The shaft **5** is directly fixed to the metal board **81** by welding. This allows the shaft **5** to be firmly fixed while getting rid of a component substantially protruding to the lower surface of the metal board **81**. This allows the reliability of the motor **1** to be improved. This also allows the motor **1** to be thinned. This contributes to a reduction in manufacturing costs for the motor **1**.

If when welding a shaft **5** to a metal board **81** covered with a coating layer **83**, the coating layer **83** melts or evaporates, the melted or evaporated coating layer can adhere to the outer peripheral part of the shaft **5**, resulting in an undulation at the outer peripheral part of the protrusion **5***c*. For instance, if the coating layer **83** is a zinc coating layer, melting of the coating layer **83** generates tin. The tin may adhere to the outer peripheral part of the shaft **5**. This can cause difficulty in putting the motor **1** in proper position using the protrusion **5***c*. If stainless steel with a relatively high manganese content is used as the material for the shaft **5**, the manganese has a relatively low melting point, and tends to evaporate. In this case, the melting or evaporation of the shaft **5** may cause foreign matter to adhere to the outer peripheral part of the shaft **5**, and the problem described above may occur more noticeably.

By contrast, in the present embodiment, the coating layer **83** is removed from a portion of the metal board **81** to form the recessed part **84**, and the recessed part **84** is directly welded to the shaft **5**. This precludes the coating layer **83** and other elements from melting or evaporating, and thus can prevent the occurrence of the problem described above.

By appropriately adjusting points irradiated with beams from the lasers L**1** and L**2** for laser welding, and an angle, intensity, and other properties of the lasers L**1** and L**2** for laser welding, a melted area may be made smaller on the shaft **5** and the metal board **81**. For instance, the points irradiated with beams from the lasers L**1** and L**2** may be made closer to a part of the shaft **5** in the neighborhood of the hole **85**. This allows the shaft **5** to be reliably fixed to the metal board **81** with relatively low output of the lasers L**1** and L**2**.

FIG. **8** is a cross-sectional view of a motor **101** according to a modification example of the present embodiment.

As illustrated in FIG. **8**, the motor **101** and the motor **1** according to the embodiment described above differ in a method for fixing the polygon mirror **70**. In other words, in the motor **101**, the spring **51** is put in proper position in the up-down direction by a protruding part **140***b*. The protruding part **140***b* is formed on an upper portion of a sleeve **140** so as to protrude in a radial direction. In such a structure, the need for providing a grip ring or a similar part to put the spring **51** in proper position is eliminated, and a number of components of the motor **101** may be reduced.

[Others]

The shaft and the recessed part of the metal board may be joined to each other by fusing. Alternatively, these parts may be welded together by a method other than laser welding.

A configuration of the components of the motor is not limited to the configuration shown in the above-described embodiment. Different configurations designed to suit the object of the present invention may be applied.

The base plate is not limited to one including the metal board and the circuit board put together. The base plate may be a base plate including wires laid on an insulating layer put on a metal board, and is not limited to the composition of the layers such as in the embodiment described above, and may be a base plate having more layers.

The motor is not limited to a motor to rotate the polygon mirror as described above. The structure for attaching the shaft to the base plate shown in the above-described embodiment can be applied to motors including base plates and being used for various purposes.

It should be construed that the embodiment described above is illustrative in all aspects, and is not restrictive. The scope of the present invention is represented by the scope of the claims and not by the above description, and it is intended that all modifications within the sense and scope equivalent to the claims are included in the scope of the present invention.

LIST OF REFERENCE SIGNS

1, **101** motor,
5 shaft,
10 rotor,
40, **140** sleeve (an example of bearing),
70 polygon mirror,
80 base plate (an example of base),
81 metal board (an example of metallic member),
83 coating layer,
83*b* opening,
84 recessed part (an example of exposed part),
85 hole,
86 welded part,
87 recessed face,
89 circuit board (an example of resin member)

The invention claimed is:

1. A motor comprising:
a shaft made of metal, and
a base including a coating layer and a metallic member covered with the coating layer,
wherein an outer peripheral part of the shaft includes a cylindrical face and a recessed face extending in a peripheral direction,
wherein the coating layer has an opening,
the metallic member includes an exposed part exposed through the opening,
the recessed face of the shaft and the exposed part are fused or welded together,
the recessed face is arranged in a base side with respect to the cylindrical face in a longitudinal direction of the shaft,
a welded part between the recessed face and the exposed part is arranged inside the exposed part,
the welded part is arranged in the recessed face side with respect to a face of the base in the cylindrical face side in the longitudinal direction of the shaft,
the cylindrical face and the face of the base in the cylindrical face side are reference surfaces.

2. The motor according to claim **1**, wherein the metallic member is a plate.

3. The motor according to claim **1**, wherein
the recessed face is entirely inside the cylindrical face in a radial direction.

4. The motor according to claim **1**, wherein the base is formed with a resin member, and wiring is formed at the resin member.

5. The motor according to claim **1**, wherein the coating layer contains zinc.

6. The motor according to claim **1**, wherein the shaft is made of martensitic stainless steel containing no lead.

7. The motor according to claim **1**, comprising:
a rotor able to rotate relative to the shaft; and
a polygon mirror attached to the rotor.

8. The motor according to claim **7**, comprising a bearing, wherein the polygon mirror is disposed at the bearing.

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